

GRAND RIVER BASIN WATER MANAGEMENT STUDY

TECHNICAL REPORT SERIES

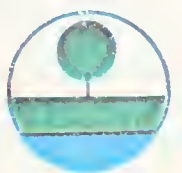


CONTINUOUS MONITORING OF DISSOLVED OXYGEN

TECHNICAL REPORT Nº 11A



GRAND RIVER IMPLEMENTATION
COMMITTEE



GRAND RIVER BASIN WATER MANAGEMENT STUDY
TECHNICAL REPORT SERIES
REPORT #11A

CONTINUOUS MONITORING OF DISSOLVED OXYGEN
1979 ADDENDUM

PREPARED FOR THE GRAND RIVER IMPLEMENTATION COMMITTEE BY:

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FOREWORD

Technical Report #11A is an addendum to Technical Report #11: "Continuous Monitoring of Dissolved Oxygen", January 1980. It is one of a series of technical documents prepared for the Grand River Basin Water Management Study. The project described herein was undertaken through the Grand River Study Team at the request of the Grand River Implementation Committee.

The material contained in these reports is primarily technical support information and, in itself, does not necessarily constitute policy or management practices. Interpretation and evaluation of the data and findings, in most cases, cannot be based solely on this one document but should be analysed in light of other reports produced within the comprehensive framework of the overall study. Questions with respect to the contents of this report should be directed to the Co-ordinator of the Grand River Basin Water Management Study, Water Resources Branch, Ministry of the Environment, 135 St. Clair Avenue West, Toronto, M4V 1P5.

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SUMMARY AND CONCLUSIONS

The Grand River Basin Water Management Study was initiated in 1975. Originally, a network of seven continuous monitoring stations, monitoring various water quality parameters (dissolved oxygen (DO), temperature), was established. In 1978-79, two more stations were added, bringing the total to nine (Figure 11). Analysis of the data from the period 1975-78, along with comprehensive discussions of the monitoring systems and data processing procedures involved, are presented in Technical Report #11 "Continuous Monitoring of Dissolved Oxygen". Technical Report #11A deals with the continuous monitoring of dissolved oxygen at nine stations in the Grand River basin during 1979 and is meant to update Technical Report #11.

The results of statistical and probabilistic analyses of the DO data collected for the nine stations during 1979, and a comparison of violation analysis for the three objectives: the old MOE objective of 5 mg/L, the current provincial objective for warm water biota (47% saturation) and 4 mg/L, the approximation in mg/L of the current percentage saturation Provincial Water Quality Objective (PWQO), are presented.

The following conclusions summarize the results of the analyses presented in this report.

1. At Bridgeport in the Grand River (Station E2) the DO levels were generally acceptable, above 5 mg/L, with exceptions occurring in June, when DO was below 4 mg /L for about 12% of the time.
2. The DO at Woolner Flats (Station E6) remained at generally above PWQO levels throughout the year. Provincial objectives were violated only in June for a short time period.
3. On the Grand River at Blair (Station N134) dissolved oxygen levels were generally above the present provincial objective. One day of extreme violation occurred in each of the summer months.

4. Data for the Speed River at Guelph (Station E3) show generally acceptable DO levels. In March, severe DO depletion occurred for four days due to a storm event.
5. At Station N135, Glen Christie on the Speed River, DO was in constant violation of the Provincial objective from June to October. Of the nine continuous monitoring stations, Station N135 showed the lowest dissolved oxygen levels.
6. The DO levels at Preston on the Speed River (Station E5) were generally above the PWQO. In July, the DO was below 4 mg/L for 30% of the time.
7. At Glen Morris on the Grand River (Station E4), the DO levels were generally acceptable, and never fell below 4 mg/L. The provincial objective of 47% saturation was in violation for a very short time in July.
8. The best DO conditions of all nine continuous monitoring stations occurred at Newport Bridge (Station E7) in the Grand River. The DO objective was never violated throughout the monitoring period.
9. At Brantford, Station E8 on the Grand River, DO levels were acceptable, and only dropped below 4 mg/L for short periods during the summer months.
10. Generally, the 4 mg/L level was violated least frequently at the nine stations during 1979, while the 5 mg/L level was violated most frequently. The Provincial Water Quality Objective of 47% saturation was violated slightly more frequently than the 4 mg/L level.

1 INTRODUCTION

1.1 PURPOSES OF CONTINUOUS MONITORING OF WATER QUALITY

Continuous water quality data are being gathered in the Grand River Basin to provide information about daily as well as long-term changes and trends in water quality for water resource management, and to provide data for the development and verification of a continuous water quality simulation model, which will be used in the basin study to evaluate various management alternatives. The continuous monitoring data can be used to determine frequencies of violation of provincial water quality objectives for selected parameters and time periods, as well as identify changes in water quality due to specific event-oriented sources, such as storm runoff or reservoir releases.

Potentially, the continuous monitoring data could be used to evaluate a real-time control system, whereby water quality would be managed by controlling reservoir releases, water takings for water supply and control of treatment plant operations, in response to observed poor water quality.

1.2 SITE SELECTION

The nine continuous monitoring stations were placed at strategic points in the Grand and Speed Rivers (Figure 11). The stations at the Canadian Gypsum Plant near Guelph on the Speed River, and at Bridgeport near Waterloo on the Grand River, record water quality upstream of the megalopolis area of the basin. All the other stations are located downstream of the defined mixing zones of major discharge points.

2.1 GENERAL

In 1979 data from the EIL and NERA monitors were processed using the specially developed computer programs utilized for the data collected for the period 1975-1978 (see Technical Report 11 for details concerning equipment and processing procedures).

The large volume of data obtained from the continuous monitor network necessitated a concise summary which retained the most important characteristics of the data. The approach taken was consistent with the requirements of the continuous monitoring data for calibration and verification of the Grand River water quality Simulation Model (GRSM). The data reduction and summary procedures were the same as those utilized for Technical Report 11.

The raw data and statistical summary tables for the period May 1975-December 1979 are on file and available on request, and are not presented in either Technical Report 11 or 11A due to the large volume of data.

2.2 DAILY STATISTICS

Daily statistics (based on a 24 hour period, from midnight one day to midnight the next day) were computed using the NERA and EIL computer programs developed by MOE, Water Resources Branch, Rivers Systems staff (see Technical Report 11). The following output summaries were provided:

- i) daily mean temperature ($^{\circ}\text{C}$) and DO (mg/L)
- ii) daily minimum temperature ($^{\circ}\text{C}$) and DO (mg/L) and times of occurrence
- iii) daily maximum temperature ($^{\circ}\text{C}$) and DO (mg/L) and times of occurrence.

Parts of the output were used to derive exceedence probability distributions for DO, shown graphically in Figures 1-9 and described below. The percentage probability of exceedence of each value was calculated by computer, ranking the data for a given month in ascending order of DO concentration, and using the equation

$$P = \frac{100 \cdot m}{N+1}$$

where: P = percentage probability of exceedence of a given value;

m = ranking of each data value; and

N = total number of data points in the month.

This probabilistic analysis was done for mean, maximum and minimum daily DO concentrations for all nine stations for the recording period January 1979-December 1979. After plotting the data on semi-log-probability paper, it was found that most of the data fit a straight line, i.e. showed a log-normal distribution. This shows the original data are a random sample from a normally distributed population, and thus error due to instrument bias can be considered to be minimal.

2.3 GRAND RIVER AT BRIDGEPORT - STATION E2

Station E2 is the upstream control station on the main Grand River. The probability distribution plots of maximum, mean and minimum daily DO for this station are presented in Figure 1. Generally, the difference between maximums and minimums is much less in the winter months than in summer and fall. DO is generally above 5 mg/L, and only in June does it drop below 4 mg/L for a short period of time. For the most part, data follow a log-normal distribution.

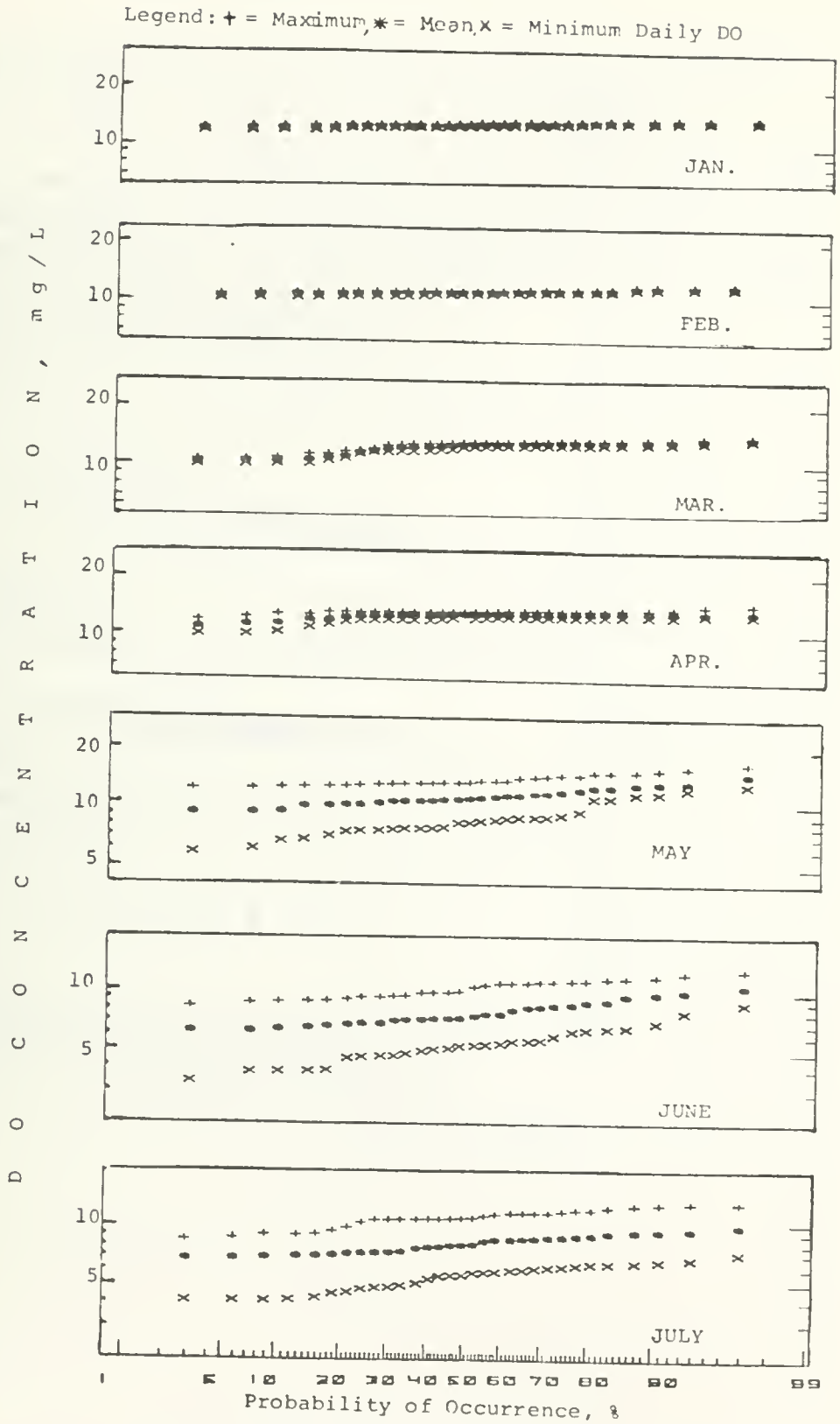


FIGURE 1 - PROBABILITY DISTRIBUTION OF DO LEVELS
AT STATION E2 - BRIDGEPORT

Legend: + = Maximum, * = Mean, x = Minimum Daily DO

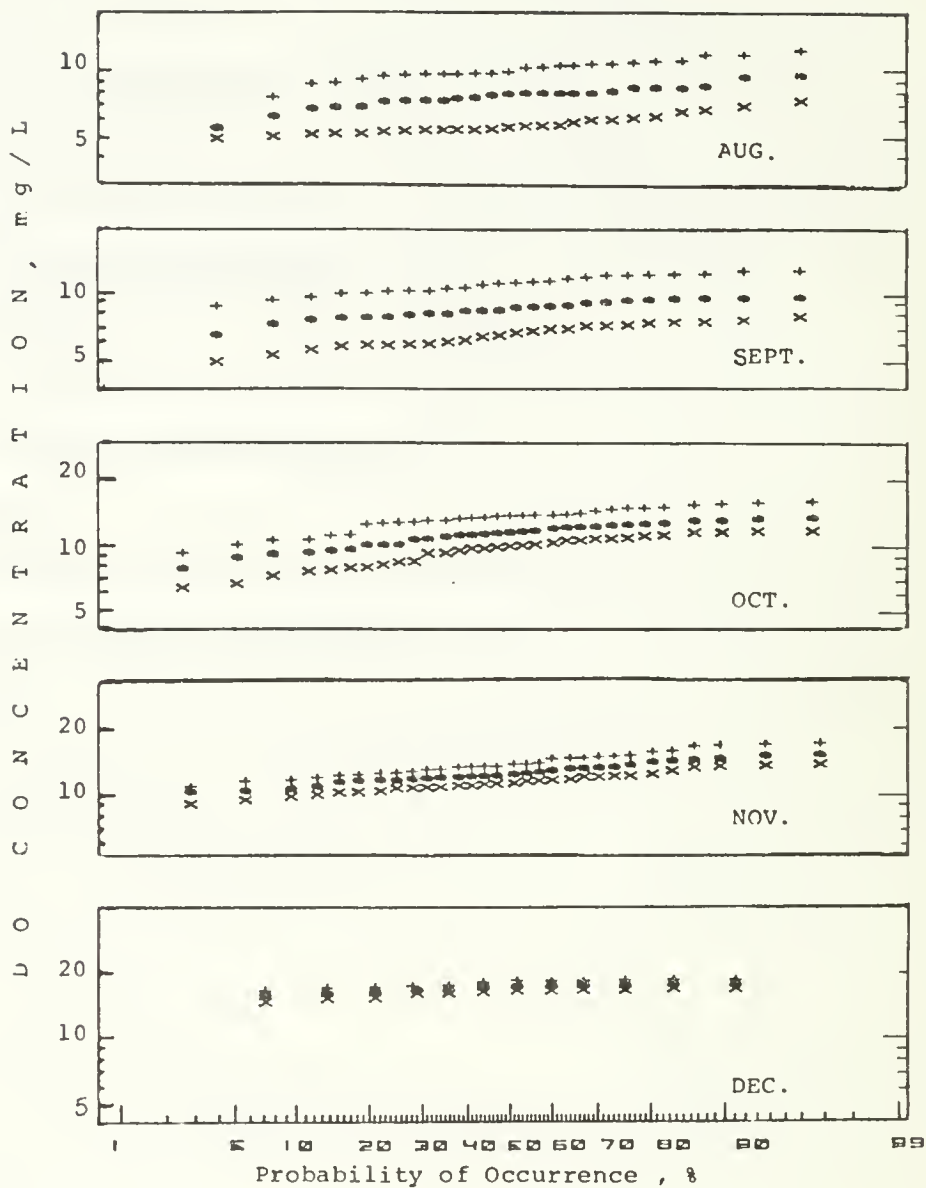


FIGURE 1 - CON'T.

The probability distribution plots of maximum, mean and minimum daily DO values at station E6, located between Waterloo and Kitchener on the main Grand River, are presented in Figure 2. Data were not available for most of March, April and part of May. The difference between maximum and minimum values is greatest in the summer and fall months, and almost negligible in winter. DO never drops below 4 mg/L.

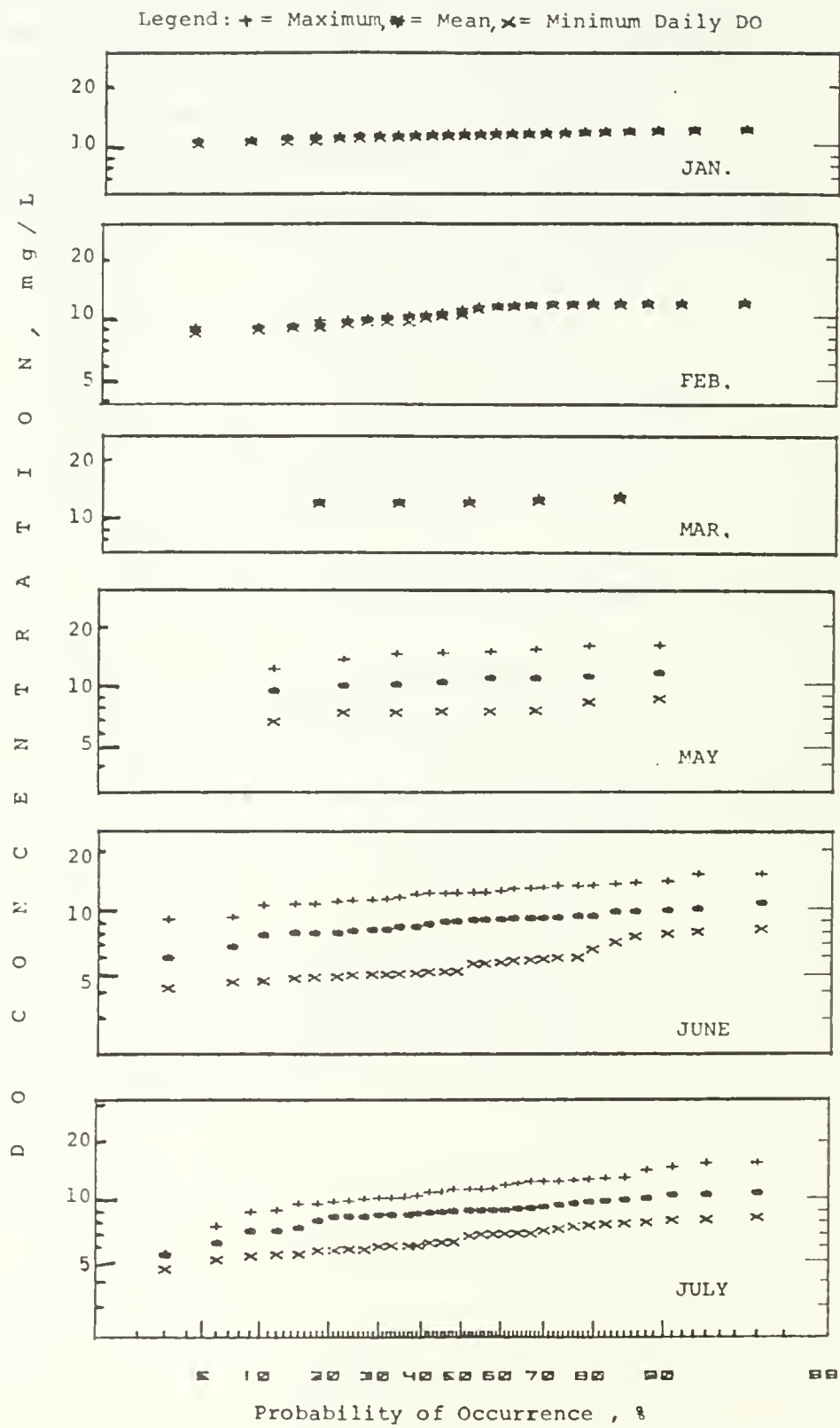


FIGURE 2 - PROBABILITY DISTRIBUTION OF DO LEVELS
AT STATION E6 - WOOLNER FLATS

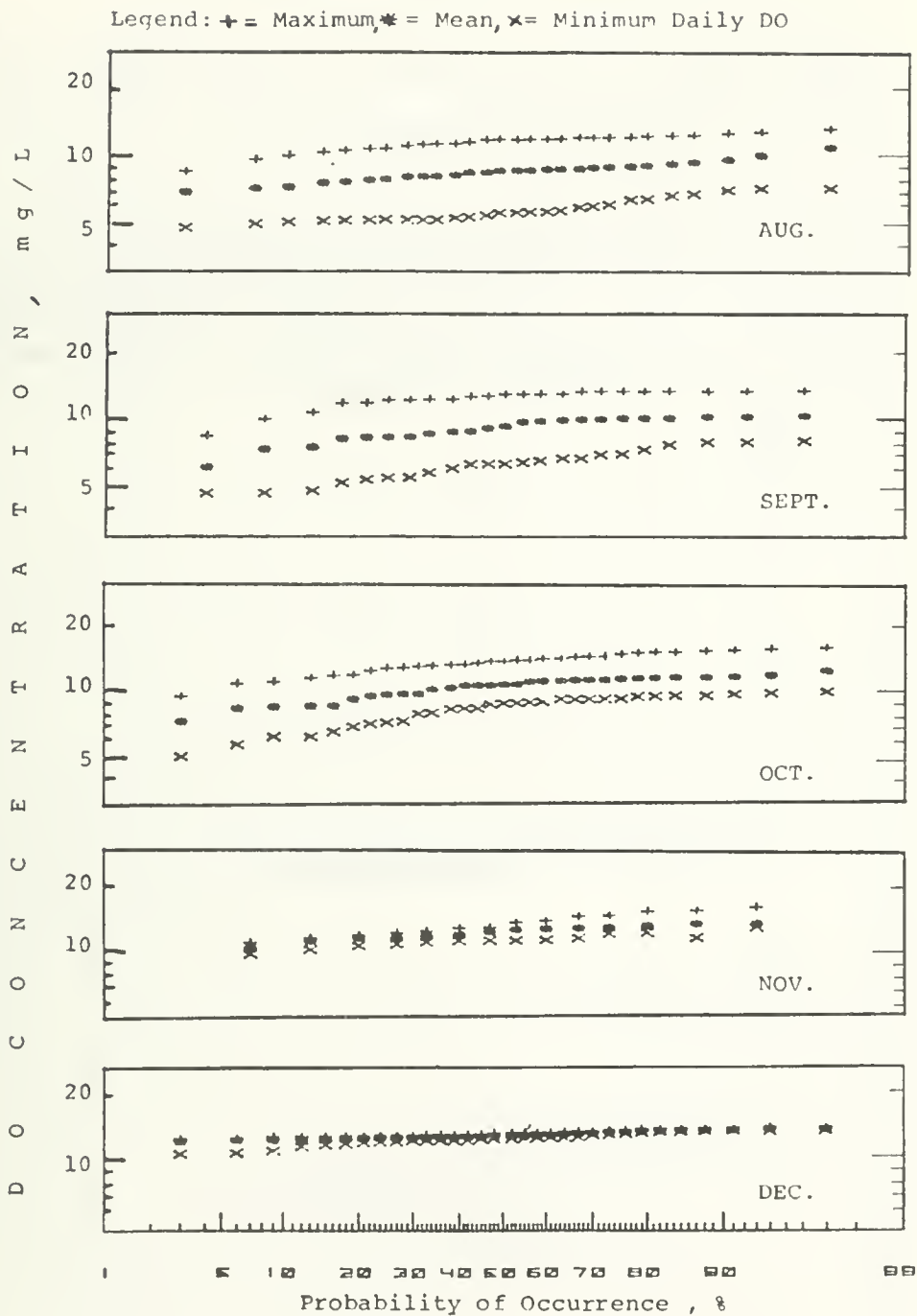


FIGURE 2 - CON'T.

Figure 3 presents the DO probability distribution plots from readings taken at the NERA monitoring station N134, situated on the Grand River between Kitchener and the Grand-Speed confluence. The months of May, June, July and October all show one very low minimum daily DO reading. Judging from the corresponding maximum daily and mean daily DO values, these odd minimum values may be due to instrument failure. Otherwise, DO values are generally above the PWQO. Data for November are not available. The NERA unit was replaced by an EIL station in November.

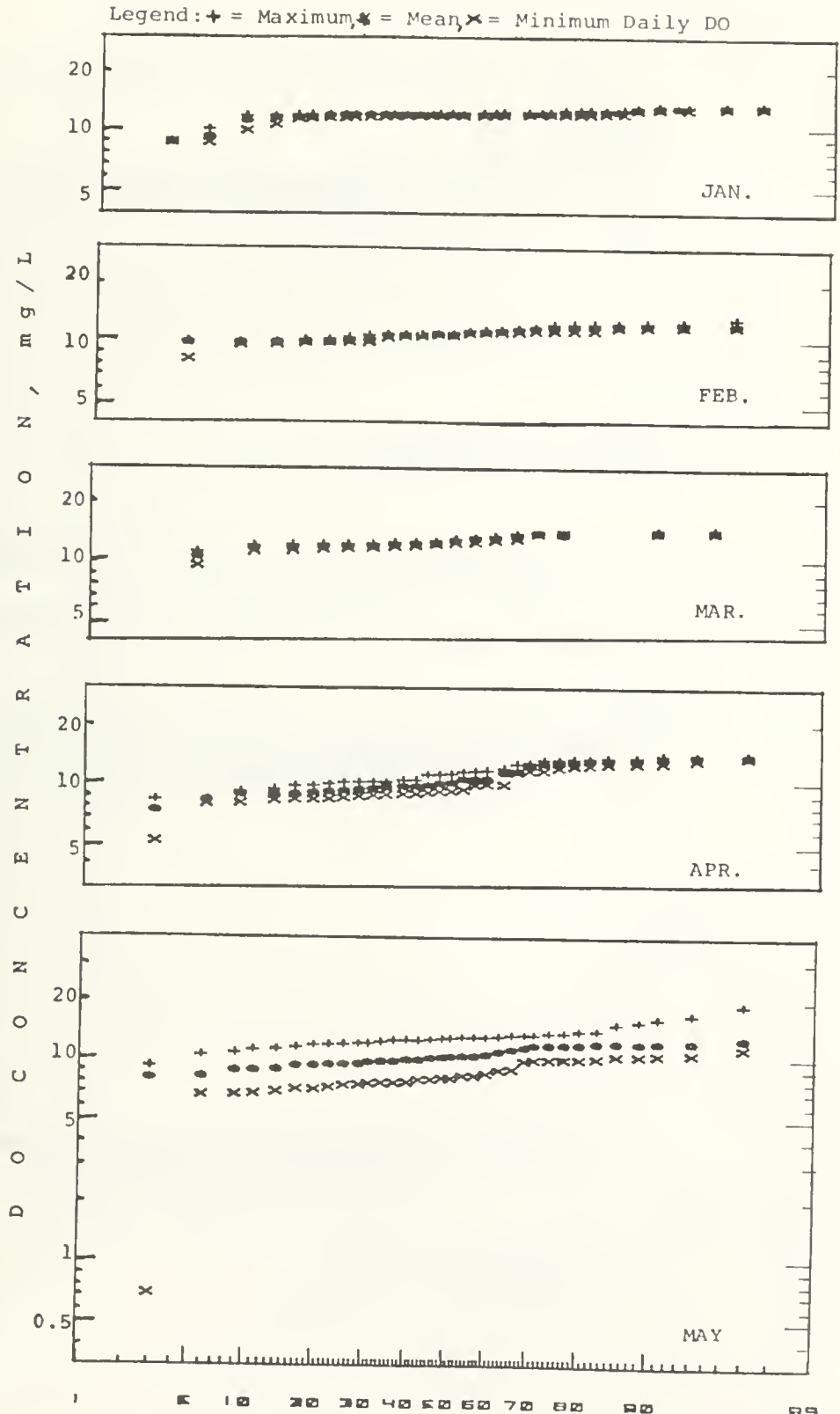


FIGURE 3 - PROBABILITY DISTRIBUTION OF DO LEVELS
AT STATION N134 - BLAIR

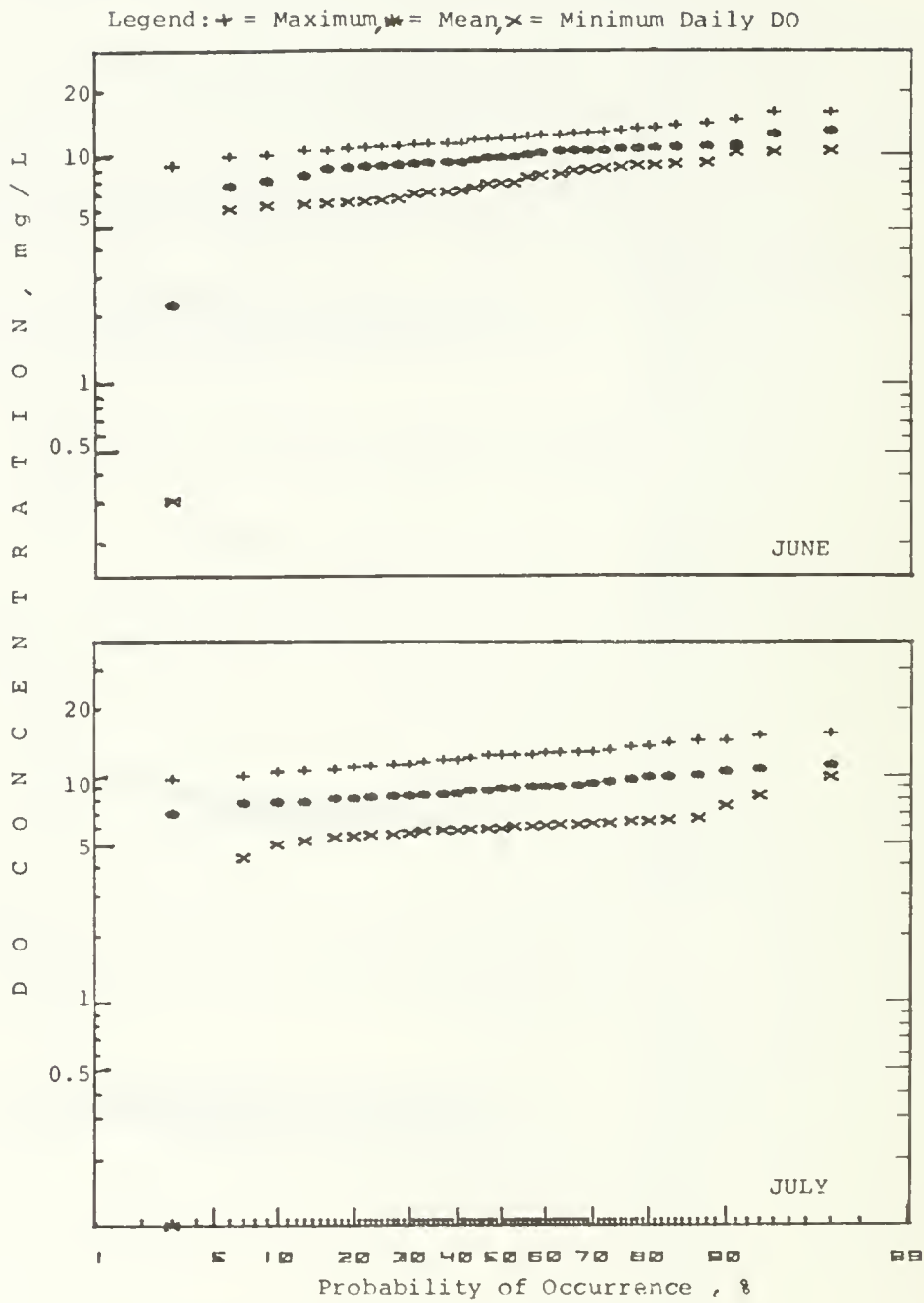


FIGURE 3 - CON'T.

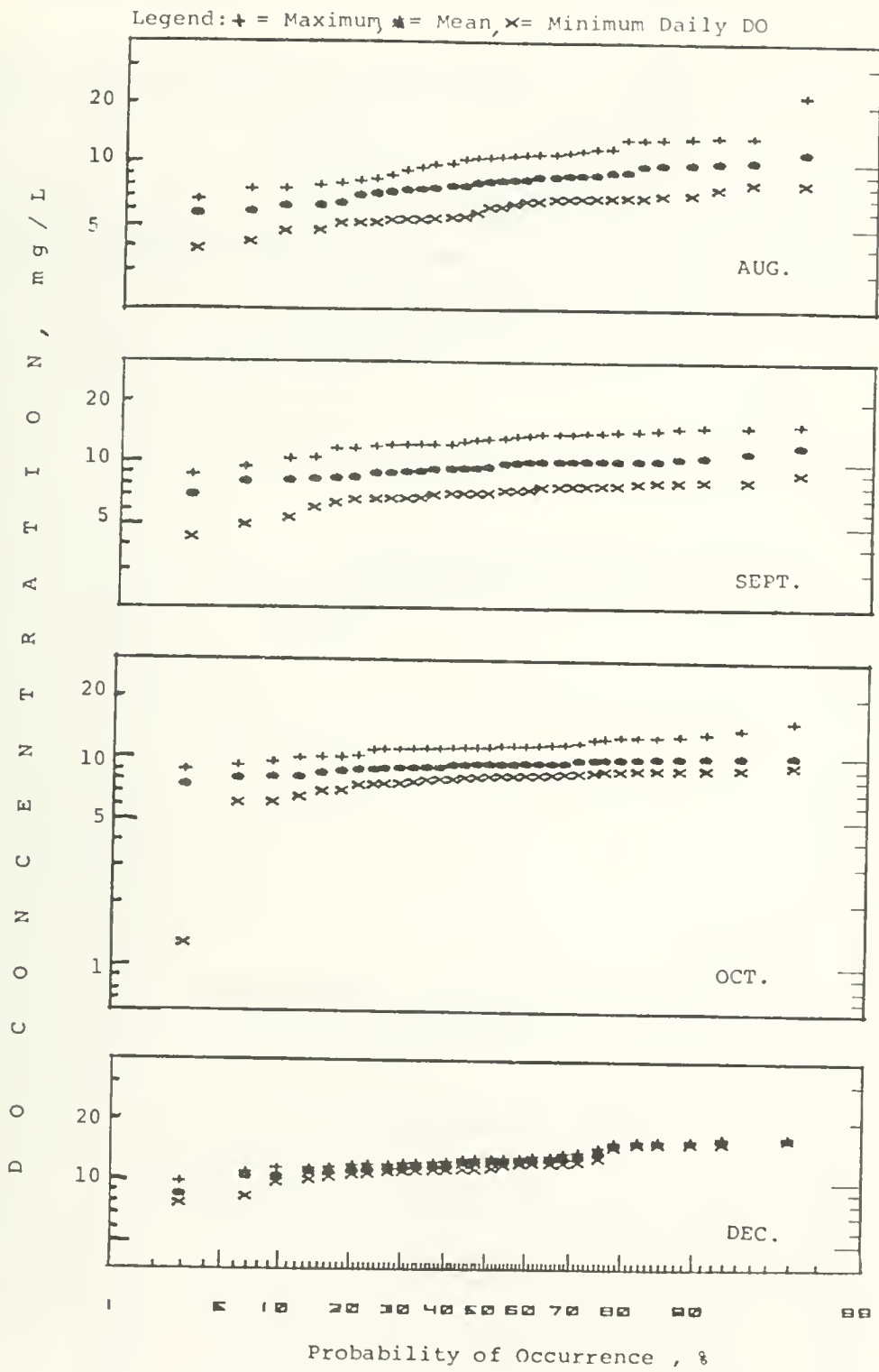


FIGURE 3 - CON'T.

2.6 SPEED RIVER AT CANADIAN GYPSUM PLANT NEAR GUELPH - STATION E3

Figure 4 presents the DO probability distribution plots for Station E3 - the upstream station on the Speed River. In March, a storm event occurred, dramatically reducing DO for several days. Otherwise DO levels are generally acceptable, never below 4 mg/L, and below 5 mg/L for only short time periods in May and June. Data generally follow a log-normal distribution.

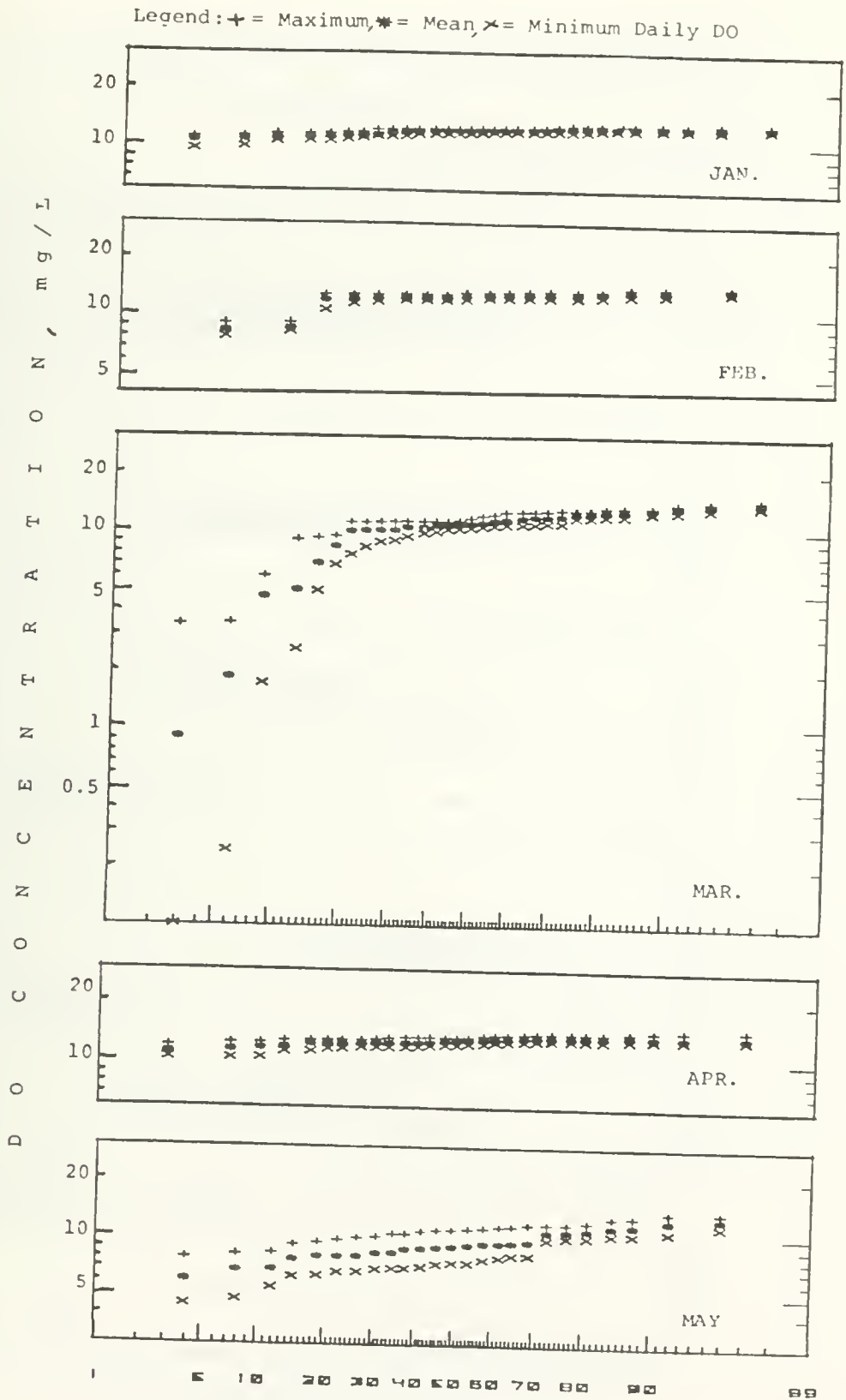


FIGURE 4 - PROBABILITY DISTRIBUTION OF DO LEVELS
AT STATION E3 - GUELPH.

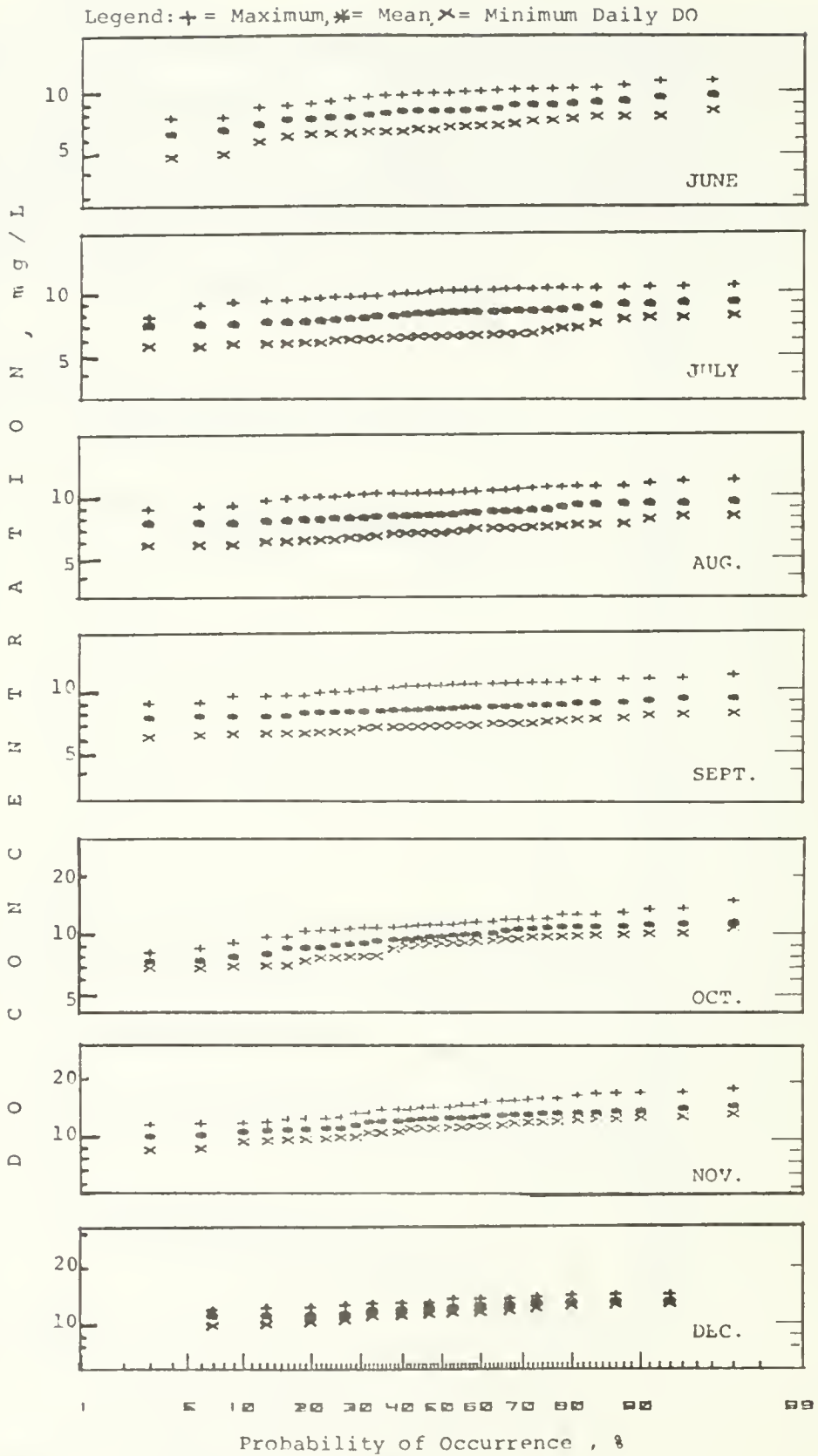


FIGURE 4 - CON'T.

The DO probability plots for the NERA monitoring Station N135, located below the Guelph Water Pollution Control Plant (WPCP), are presented in Figure 5. Minimum DO levels are generally acceptable in the winter months but drop to, and remain in non-compliance with, the provincial water quality objective of 47% saturation for most of the time between June and November. In July, minimum daily DO reaches 0 mg/L, and during July, August, September and October minimum DO is never above 4 mg/L. The NERA unit was replaced by an EIL instrument in October.

GLEN CHRISTIE 1979

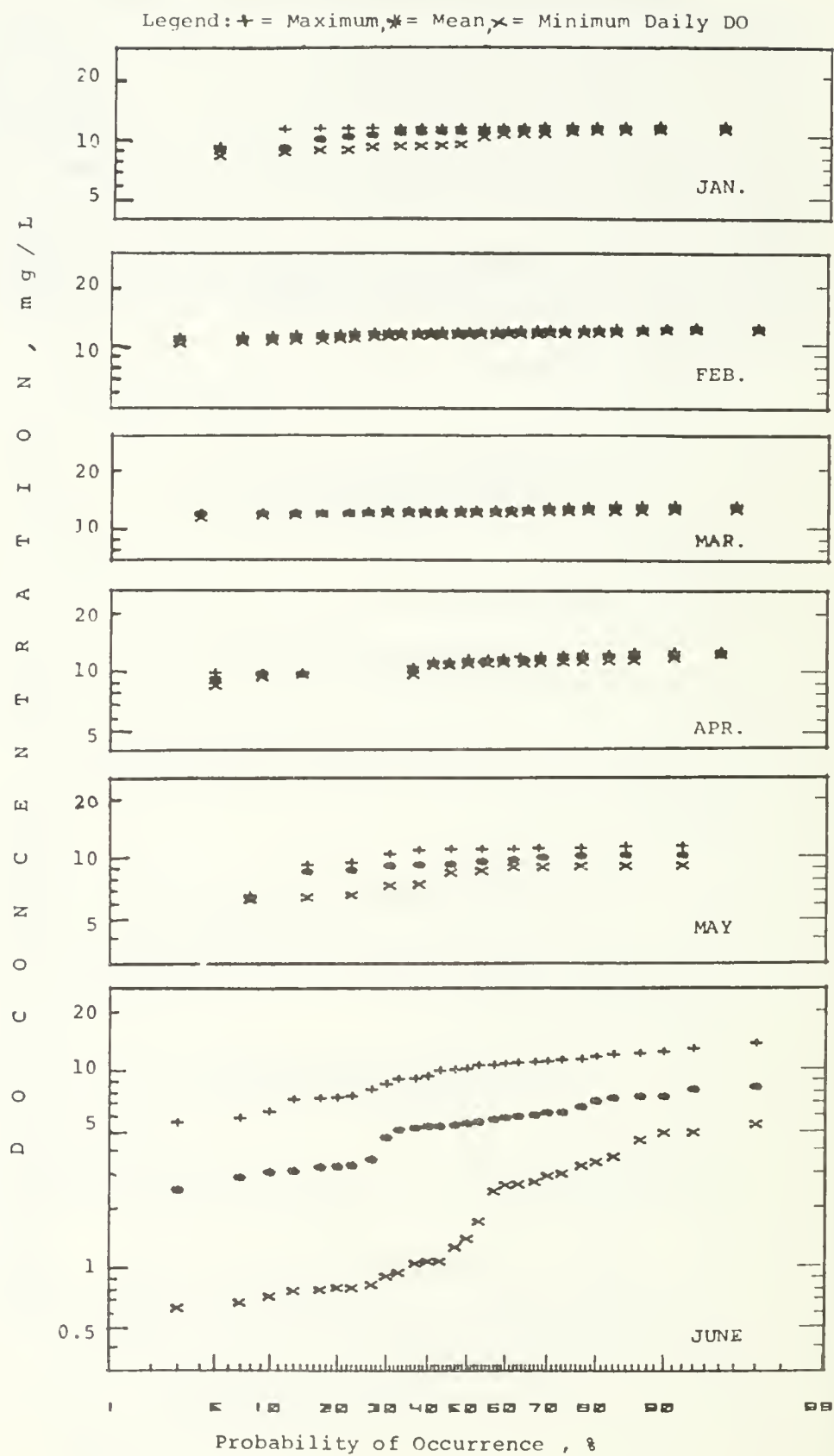


FIGURE 5 - PROBABILITY DISTRIBUTION OF DO LEVELS
AT STATION N135 - GLEN CHRISTIE

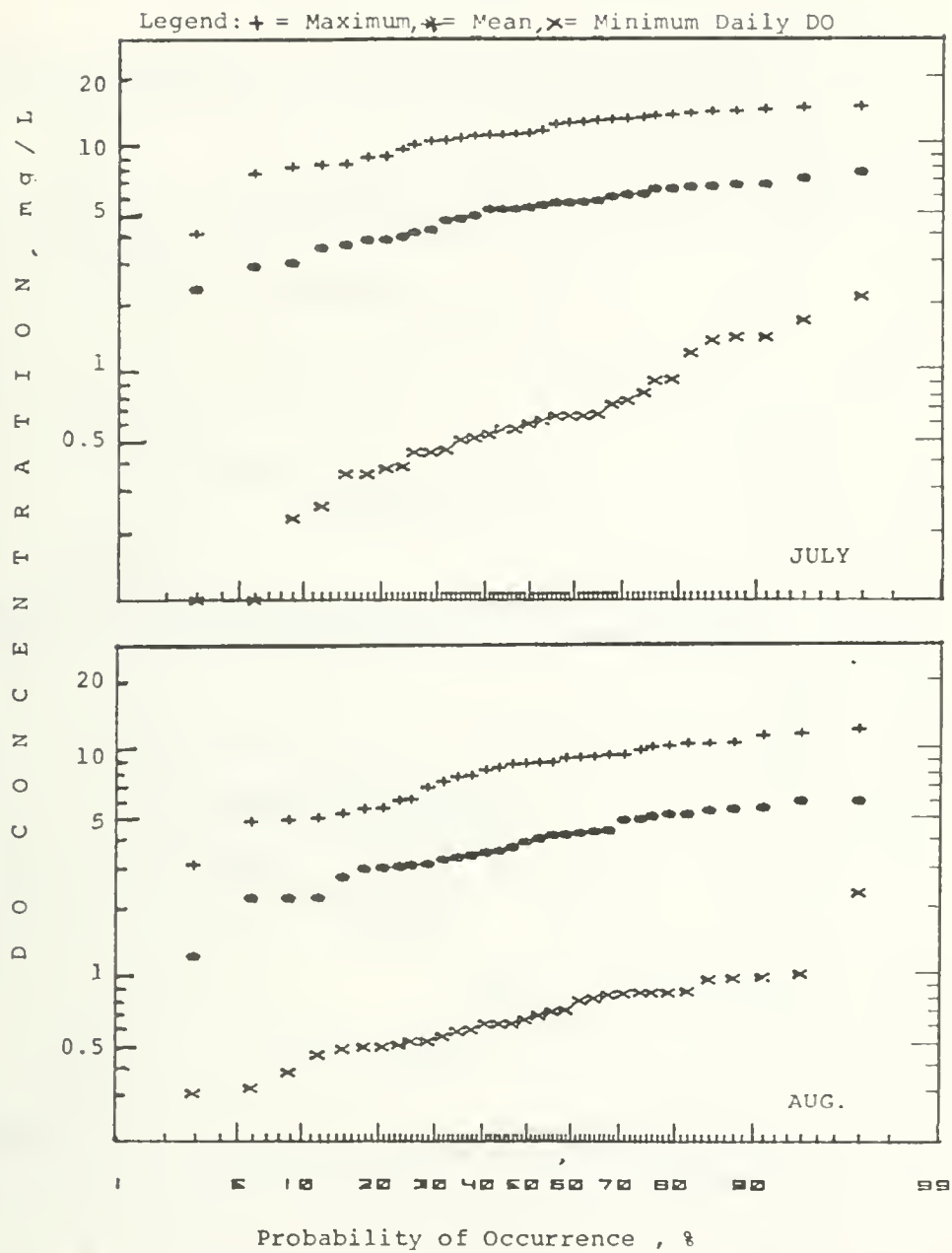
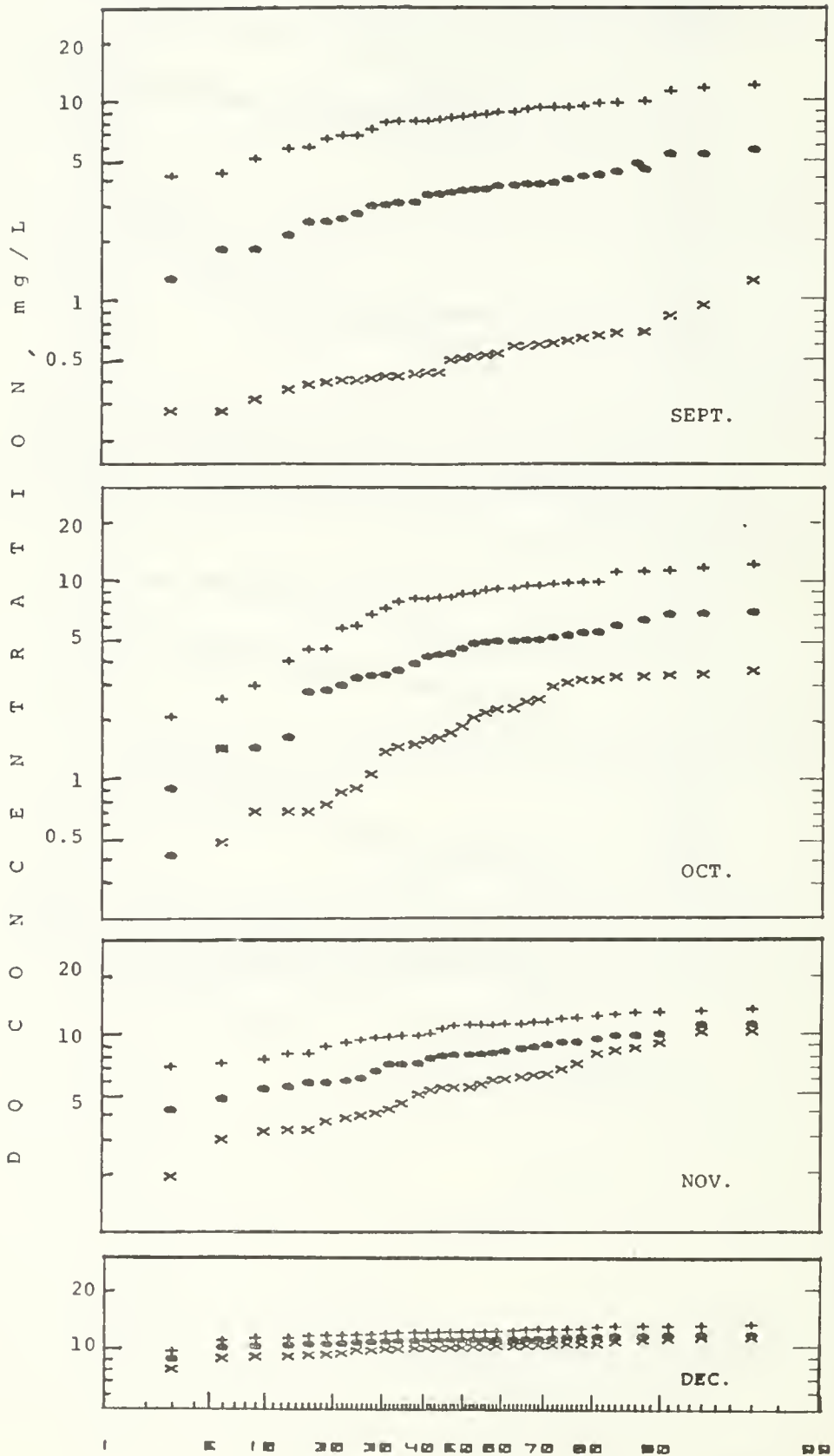


FIGURE 5 - CON'T.

GLEN CHRISTIE 1979

Legend: + = Maximum, * = Mean, X = Minimum Daily DO



Probability of Occurrence , %

FIGURE 5 - CON'T.

The DO probability distributions at station E5, located near the mouth of the Speed River, are presented in Figure 6. The plots show that DO values are generally above the PWQO, and only during July does DO drop below 4 mg/L for about 25% of the time. Generally, the data follow the log-normal distribution.

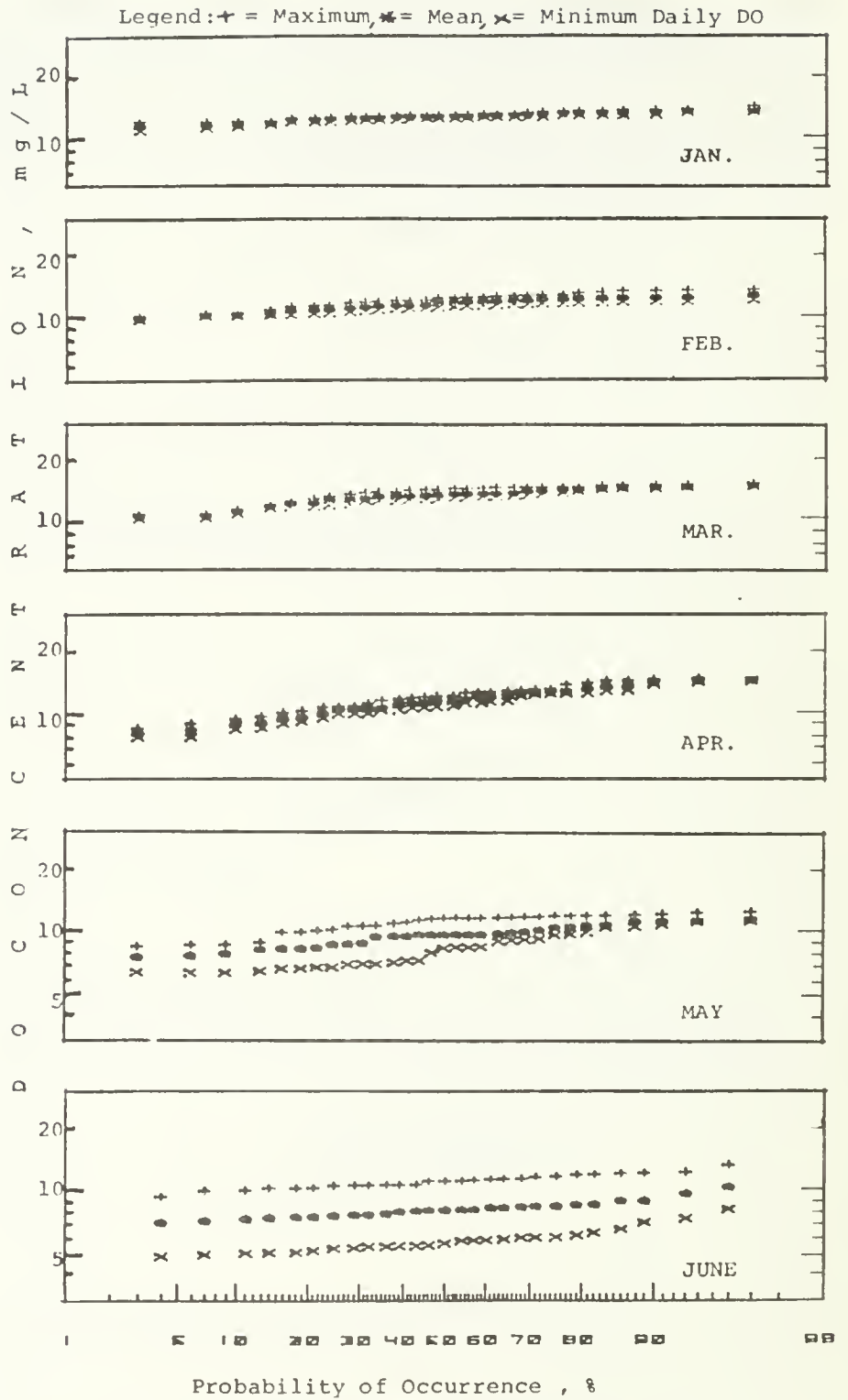


FIGURE 6 - PROBABILITY DISTRIBUTION OF DO LEVELS
AT STATION E5 - PRESTON

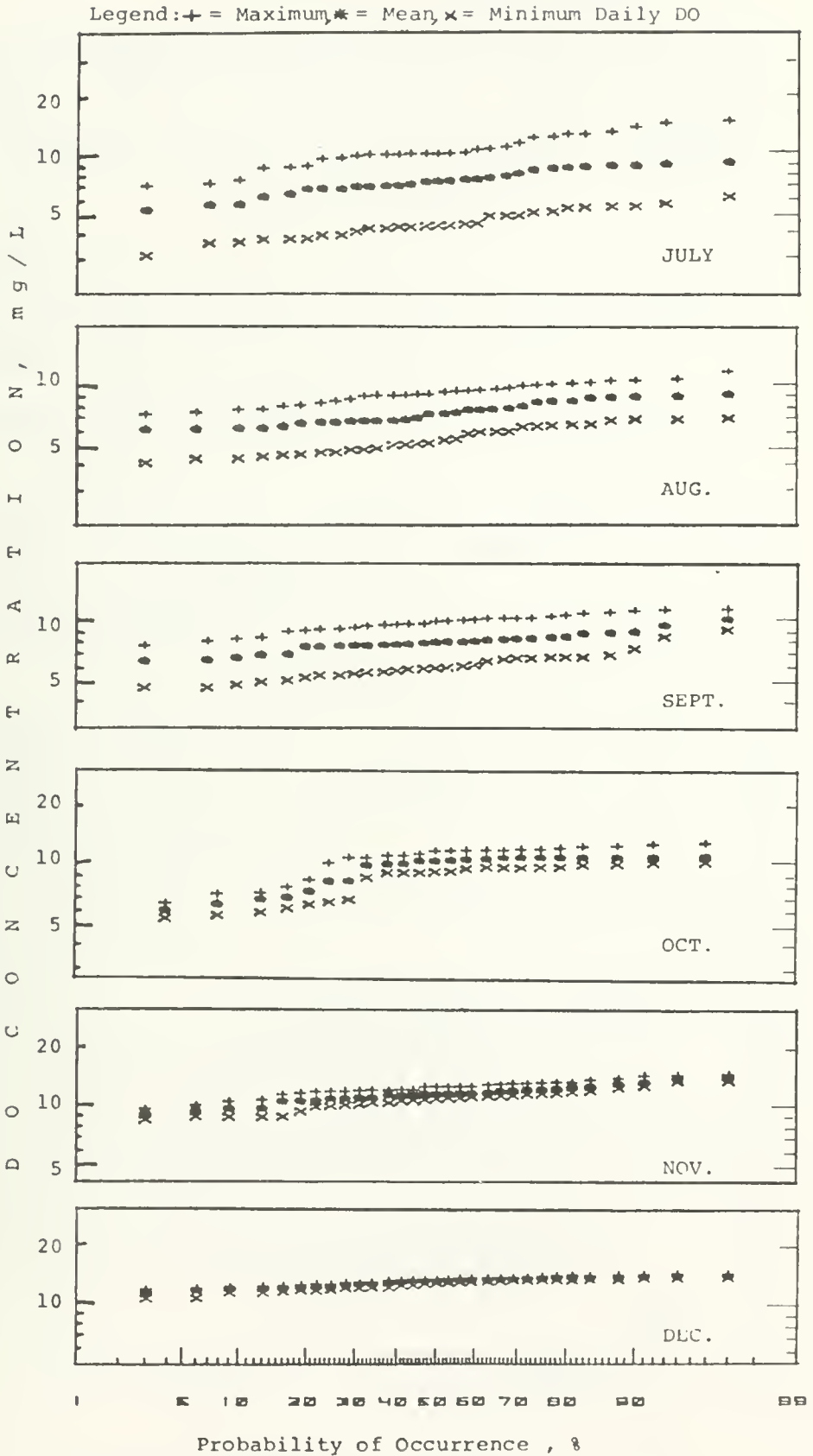


FIGURE 6 - CON'T.

Figure 7 presents the DO probability distribution plots at station E4, at the downstream edge of the central megalopolis area of the Grand River basin. The DO distributions generally follow a log-normal distribution, and DO is never in violation of the 4 mg/L criteria.

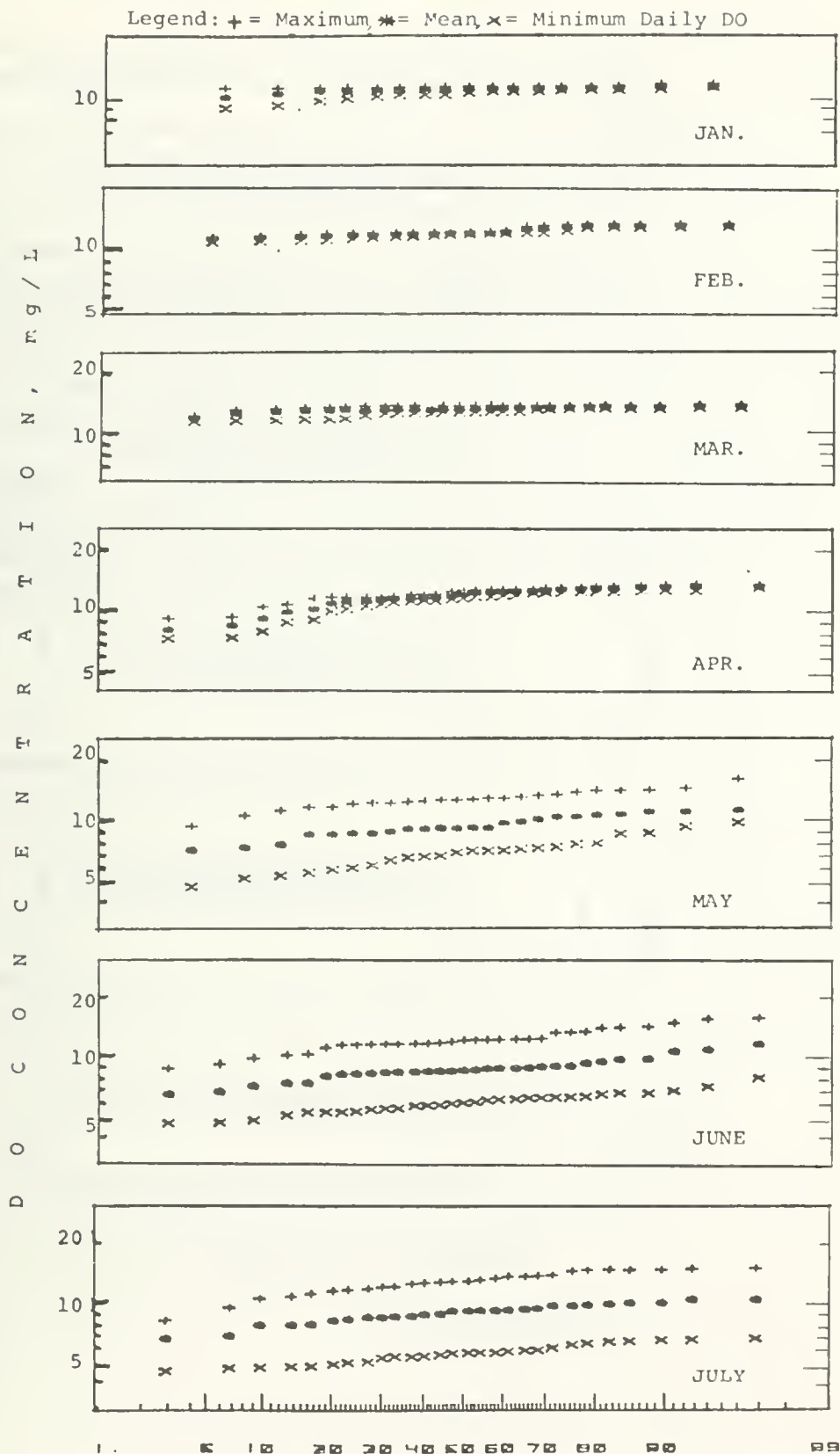


FIGURE 7 - PROBABILITY DISTRIBUTION OF DO LEVELS
AT STATION E4 - GLEN MORRIS

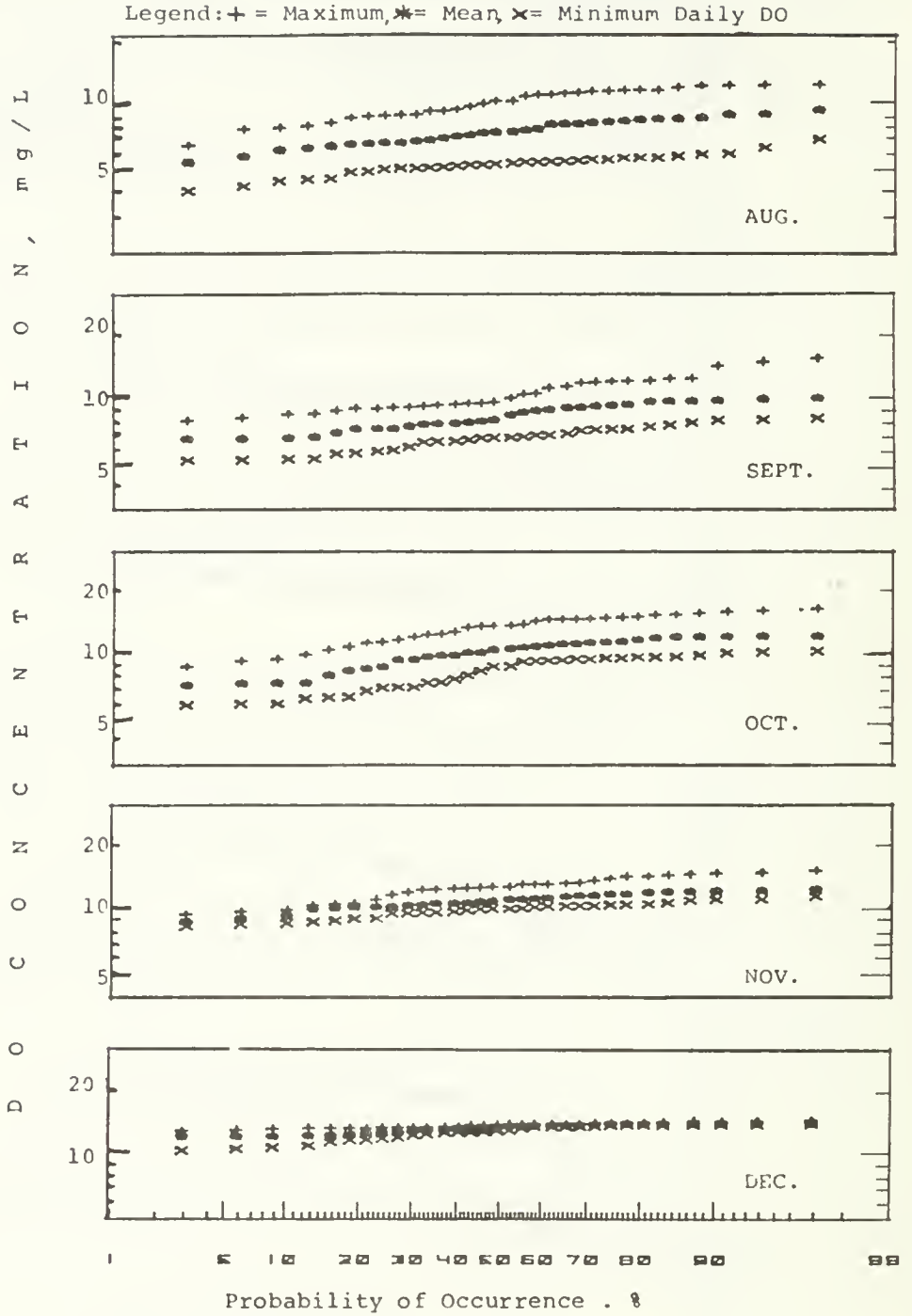


FIGURE 7-CON'T.

Station E7 is located at the Newport Street Bridge in Brantford on the Grand River. DO probability plots for the station are presented in Figure 8. DO levels are shown to be above the PWQO at this station, never violating the 5 mg/L criteria. Data for December, most of March, April and part of May are not available. Available data for March are suspect due to unusually high DO levels (up to 29 mg/L). The fact that the EIL unit stopped operating after 5 days in March supports the argument that these data are erroneous and should be disregarded. The suspect data recorded in February and all the data recorded in March are included in figure 8 for informational purposes only. These data should not be considered when comparing the results from this station to the results from the remaining eight stations. The exact cause of the error is unknown, but instrument failure should be considered as the prime reason.

NEWPORT BRIDGE 1979

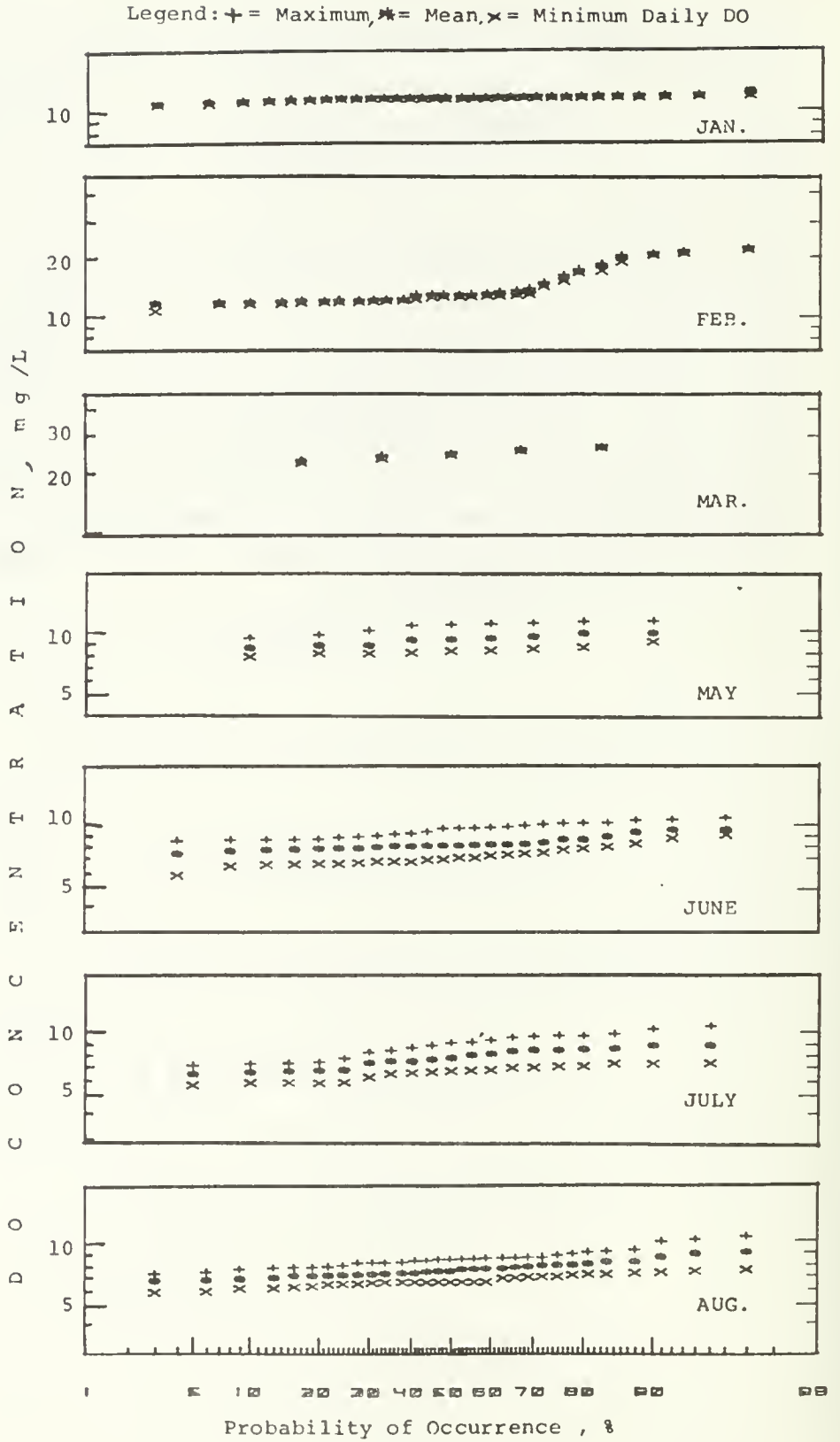


FIGURE 8 - PROBABILITY DISTRIBUTION OF DO LEVELS
AT STATION E7 - NEWPORT BRIDGE

NEWPORT BRIDGE 1979

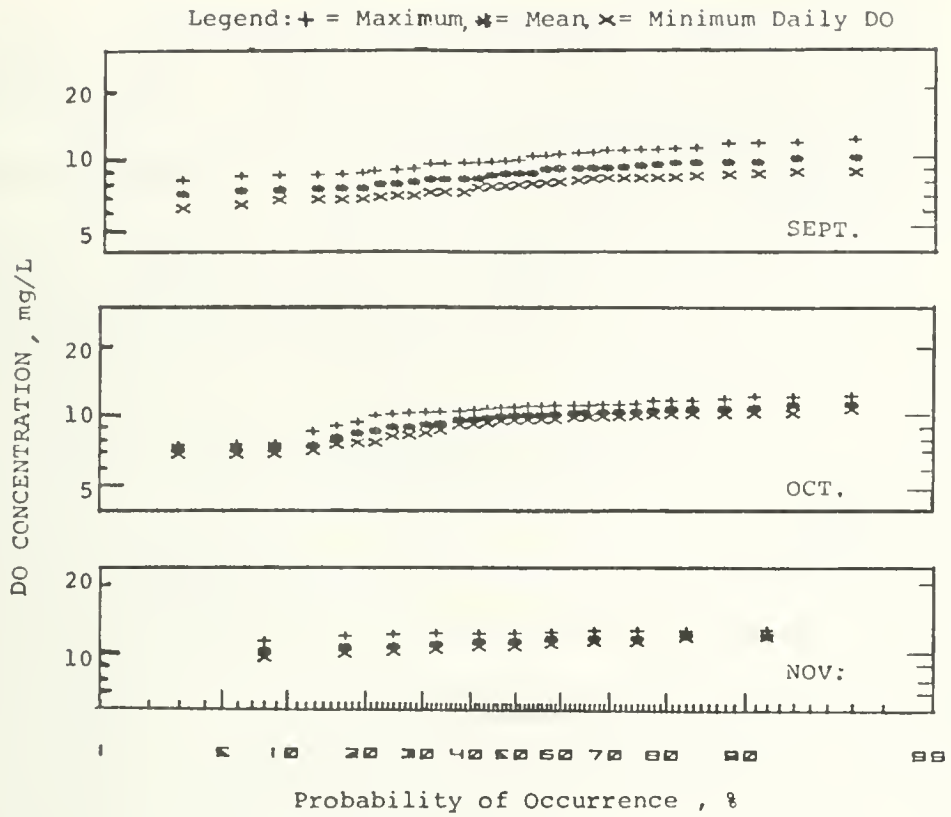


FIGURE 8 - CON'T.

2.11 GRAND RIVER AT BRANTFORD - STATION E8

Figure 9 presents the DO probability plots at Station E8, upstream of the dam at Brantford on the Grand River. Data are available for the months of May through November, during which time DO is never below 4 mg/L. Data generally follow the log-normal distribution.

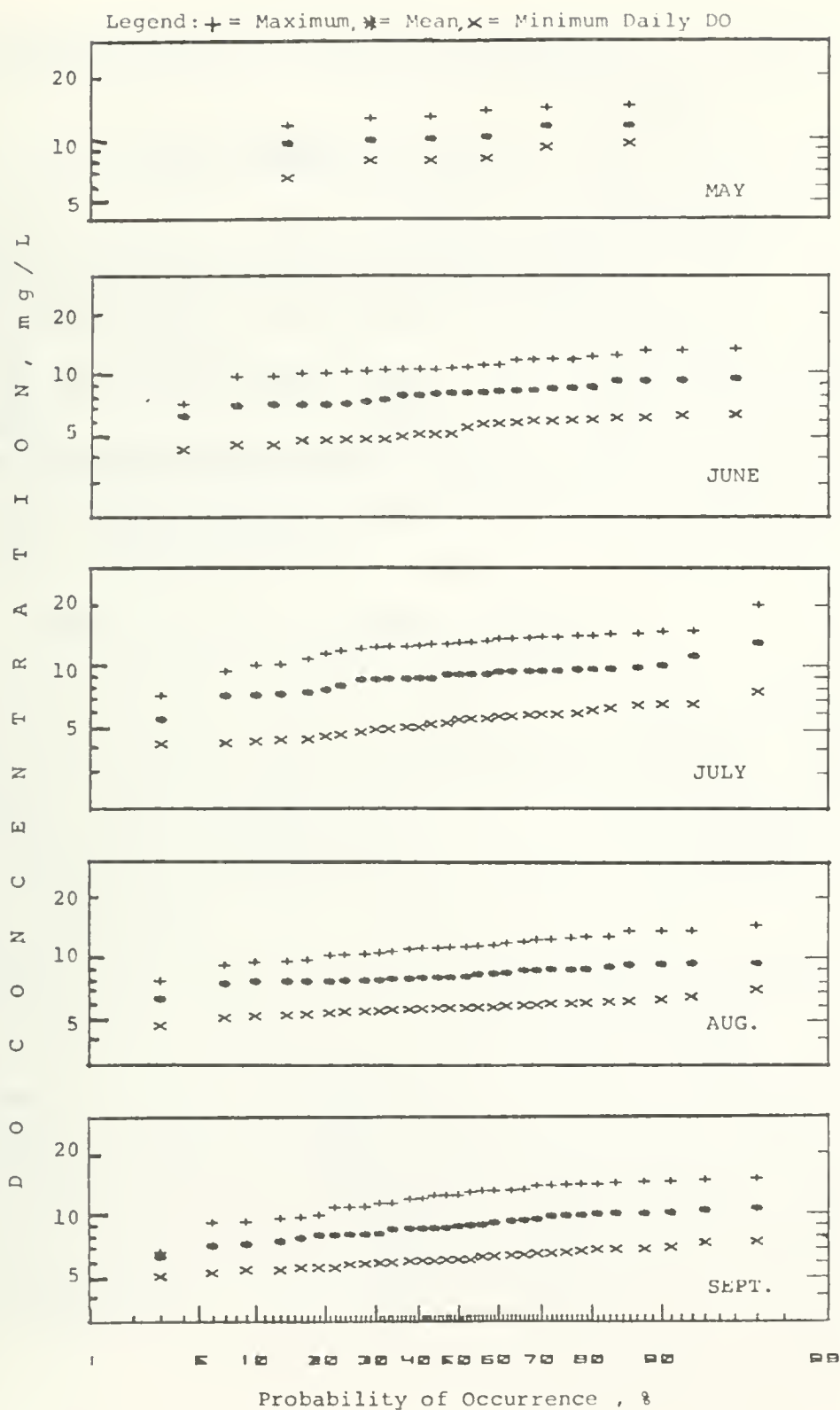


FIGURE 9 - PROBABILITY DISTRIBUTION OF DO LEVELS
AT STATION E8 - BRANTFORD

BRANTFORD 1979

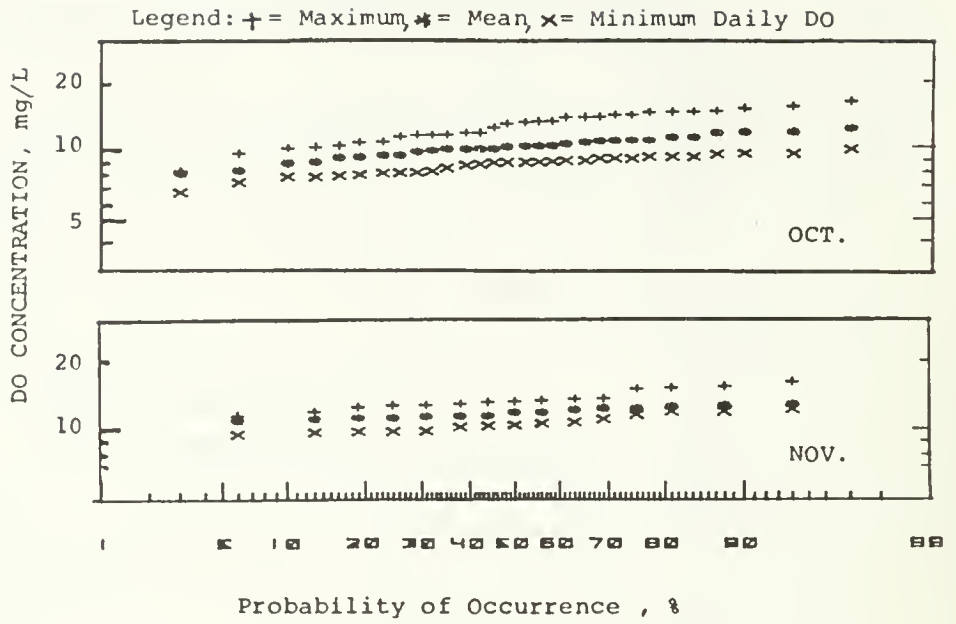


FIGURE 9 - CON'T.

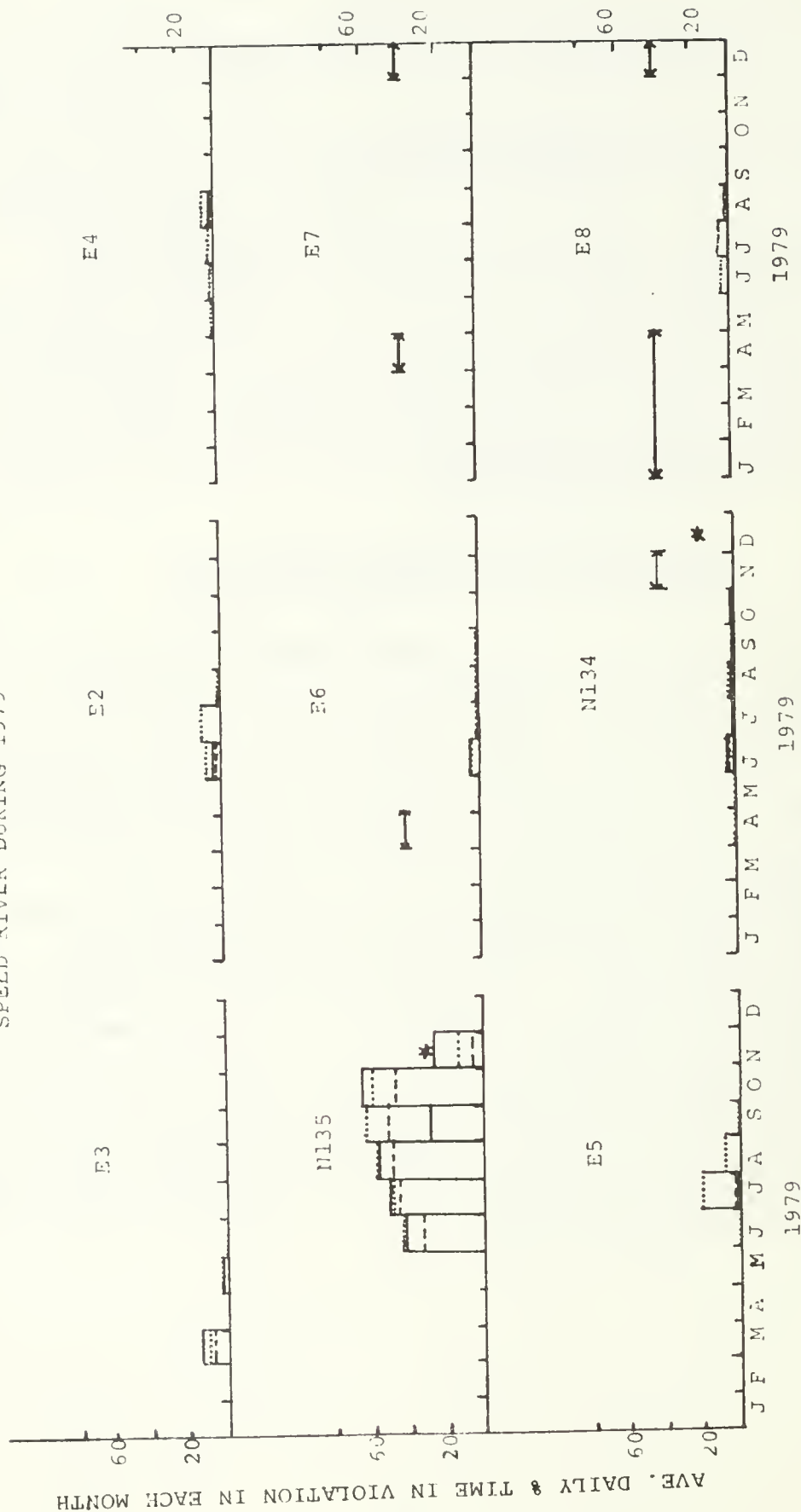
2.12 COMPARISON OF VIOLATION ANALYSIS RESULTS

Average percentage times of DO violation in each month were compared for the following levels: 4 mg/L, 5 mg/L and the provincial DO objectives for warm water biota (47% saturation). The results are presented in Figure 10. Generally, violations of the 5 mg/L level occurred most frequently, while violations of the 4 mg/L level occurred least frequently. In a few months at Stations E3 and N135 (Speed River at Guelph and Glen Christie, respectively) the percentage of violations of the PWQO was higher than the percentage of violations of the 4 & 5 mg/L values. At all other stations, the percentage of violations of the 5 mg/L level is higher than that for the PWQO. At the stations on the main Grand River (E2, E6, N134, E4, E7, E8) average percentage times of violations are generally low for 4 mg/L, 5 mg/L and the PWQO.

2.13 COMPARISON OF 1979 DATA WITH 1975-78 DATA

The data for the period January 1979-December 1979 appear to be typical of the data for the period May 1975-December 1978 at Bridgeport (Station E2), Blair (Station N134) and Guelph (Station E3). Glen Christie in 1979 (Station N135) was below the 1975-78 average; the DO depletion lasted longer than usual. During late August, the Guelph Water Pollution Control Plant, located approximately four km upstream of this location, went to primary bypass to facilitate installation of the rotating biological collector (RBC) units. This, combined with start up problems encountered by the WPCP, is probably one of the major causes of the lower than usual dissolved oxygen values recorded at this station. Fewer violations than the previous 1975-78 average occurred at Glen Morris (Station E4), Preston (Station E5) and Woolner Flats (Station E6) in 1979, no prior data are available for Newport Bridge (Station E7) and Brantford (Station E8).

FIGURE 10 - AVE. TIME OF VIOLATION OF DO CRITERIA AT
VARIOUS STATIONS IN THE GRAND RIVER AND
SPEED RIVER DURING 1979



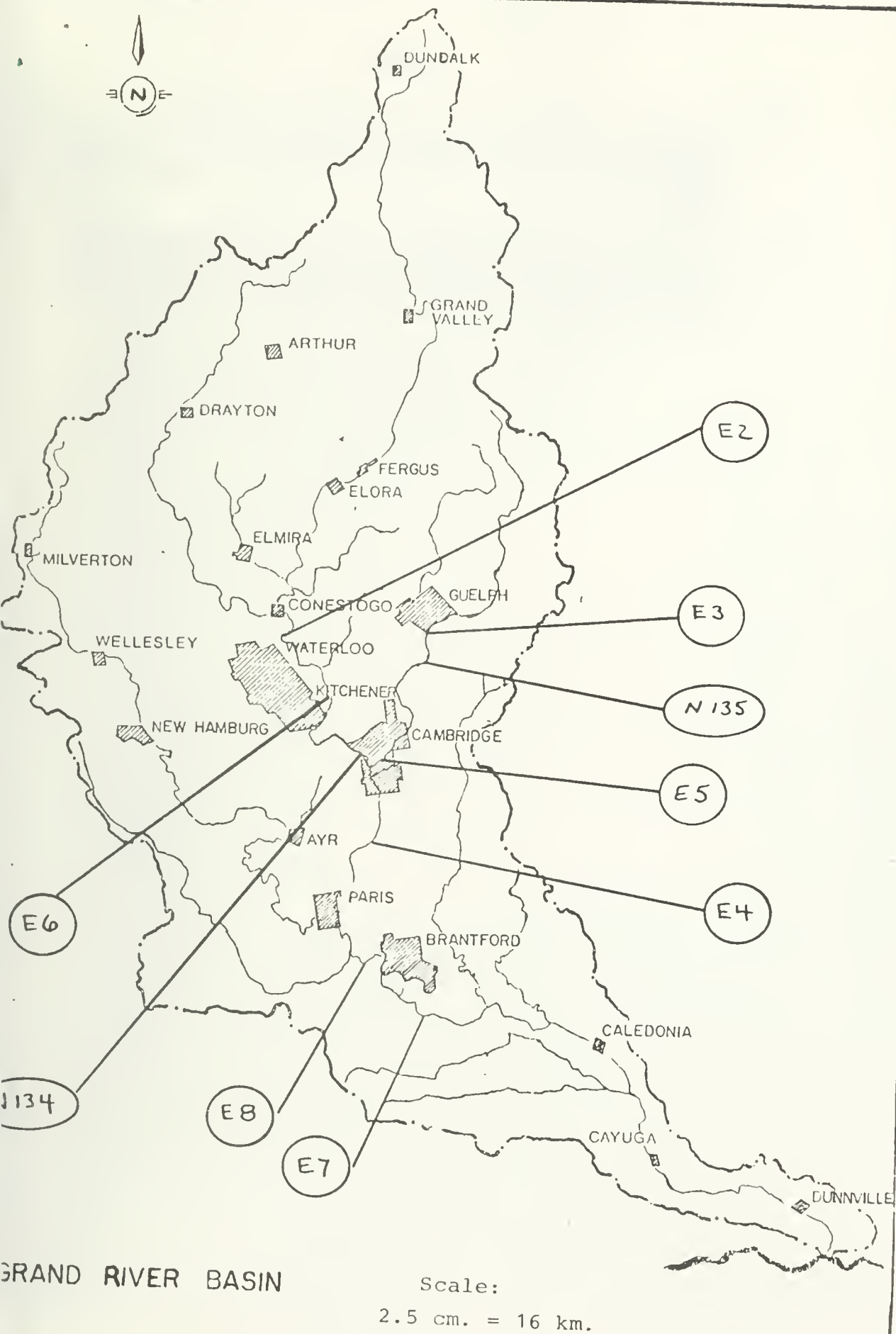


Figure 11- CONTINUOUS MONITORING NETWORK
GRAND RIVER BASIN

